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CONVERSION OF CONTOURED POLAR STEREOGRAPHIC PROJECTED DATA INTO THE ENVIRONMENTAL ACOUSTIC INTERACTIVE DATA SYSTEM (EAIDS)

ERNEST A. WILEY
JAMES J. KOHSMANN

PROPAGATION BRANCH, ACOUSTICS DIVISION

Prepared under the authority of
Commander,
Naval Oceanography Command

In support of the Oceanographic and Atmospheric Master Library, the Naval Oceanographic Office (NAVOCEANO) was tasked with updating the Arctic Sediment Thickness database. The data for this update were received as a polar stereographic chart that was prepared by H.R. Jackson. This technical note describes the conversion of these polar stereographic data into a format acceptable for input into the Environmental Acoustic Interactive Data System (EAIDS).

The programs for this conversion are given in the appendix. The source code is available through the NAVOCEANO Analysis and Data Base Section.

RELEASED FOR PUBLICATION:

F. Barter II

F. BARTER II, Acting
Branch Head
Propagation Branch

R.E. Christensen

R.E. CHRISTENSEN
Director
Acoustics Projects Division

William J. Jobst

WILLIAM J. JOBST
Director
Oceanographic Department

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Ernest A. Wiley
James J. Kohnsmann

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13. ABSTRACT *(Maximum 200 words)*
In support of the Oceanographic and Atmospheric Master Library, the Naval Oceanographic Office (NAVOCEANO) was tasked with updating the Arctic Sediment Thickness Data Base. The data for this update were received as a Polar Stereographic Chart that was prepared by H.R. Jackson. This technical note describes the conversion of these polar stereographic data into a format acceptable for input into the Environmental Acoustic Interactive Data System (EAIDS).

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I. INTRODUCTION

The purpose of this document is to provide step-by-step instructions on how to read and process digitized contour data from a polar stereographic projection. Solution of the problem has been sufficiently time consuming to warrant full documentation to avoid future replication of effort.

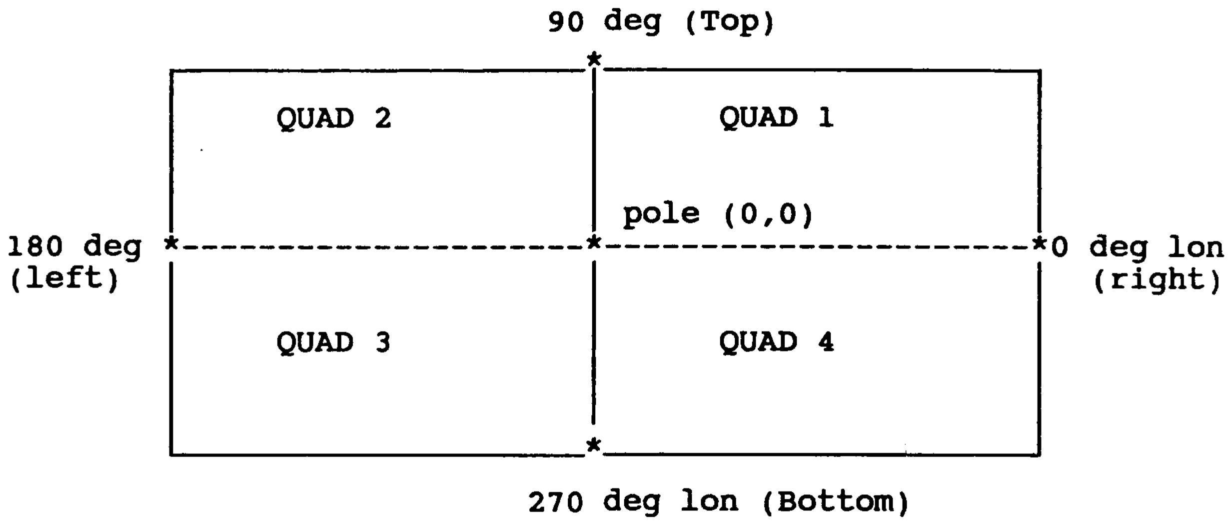
II. DIGITIZATION OF A NONRECTANGULAR CHART

A solution to the problem was devised to work within the range of software already available at Stennis Space Center. Since the digitizing programs handle data charts that are rectangular in form, an orientation was developed that would allow this form to be simulated. The entire chart was treated as if it were a square. Orientation was such that the meridian that forms 90 degrees west and 90 degrees east ran top to bottom, and the meridian that forms 180 degrees to 0 degrees ran left to right. With this orientation only a few software changes had to be made. Most of the changes involved the number of control points that were written to the output tape. The control points are used for primary chart registration. This change was simple because the software already lets the user specify as many control points as are necessary to define the chart. The first control point is the location in table units of the pole. The next 16 control points are the location in table units of the lowest latitude on the chart along the major meridians. These 16 points are then averaged to get the most accurate distance in table units from the pole to the lowest latitude.

The polar chart is then treated as if it were placed on a Cartesian coordinate system, with the pole being 0,0. Each x and y value is read from the input tape and checked for validity. The valid points are then written to a sequential access file. The data in this file are read back into the program and its quadrant and section are determined. Each quadrant spans 90 degrees and includes 3 sections of 30 degrees each.

III. CHART ORIENTATION

In order to have the chart digitized, an orientation had to be specified. To help facilitate the use of the digitizing software, the polar stereographic chart was treated as if it were resting on a rectangular surface (figure 1).



* Note: These are the control points. At each * there should be 4 x,y pairs, except for the pole. The pole should be the first in the set of control points, along with the points 2-5 at 0 degrees longitude, then points 6-9 at 90 degrees longitude, then 10-13 at 180 degrees longitude, and 14-17 at 270 degrees longitude. Be very sure that the number of control points on the tape is the same as the number expected or data will be lost.

Figure 1. Chart Orientation.

Once the orientation was specified, an algorithm was needed to convert the stereographic x,y values in table units to their corresponding latitude and longitude values. When this step was completed, processing the data was the same as other contourable data.

IV. CONVERSION OF X,Y VALUES INTO STEREOGRAPHIC PROJECTION

The polar stereographic projection is a conformal projection with the projection pole on the surface of the globe diametrically opposite the map pole (figure 2). Because of its conformal property, it is sometimes used for maps of large areas. The digitized rectangular coordinate values have to be transformed to geodetic coordinates. The first pair of points in the set is the x,y location of the pole. The control points located at the intersection of the minimum latitude and the major meridians are averaged to obtain an accurate measurement of the distance from the pole to the minimum latitude in table units. Using this information, compute R, which is the radius of the sphere that was stereographically projected onto the chart. This is done by using the following expression:

```
R= Rmax *.5/tan(((90 - minlat)/2)/brad))
```

where

```
Rmax  --> distance from the pole to the min. latitude
minlat--> the min. latitude on the chart
brad  --> degrees to radians conversion factor
```

Now read the remainder of the data off the tape and compute the latitude and longitude for all the data points. First compute the distance that each point lies from the pole in table units for both the x and y directions. Then solve for the hypotenuse which is called "rr".

To compute the longitudes use the following formula:

```
lon=(atan2(yp,xp))*brad
```

where

```
xp--> data position in the x direction
yp--> data position in the y direction.
```

To compute the latitudes use the following formula:

```
lat=90 -(2* brad*atan((rr* .5)/R))
```

where

```
rr--> hypotenuse
R --> radius of the projected sphere.
```

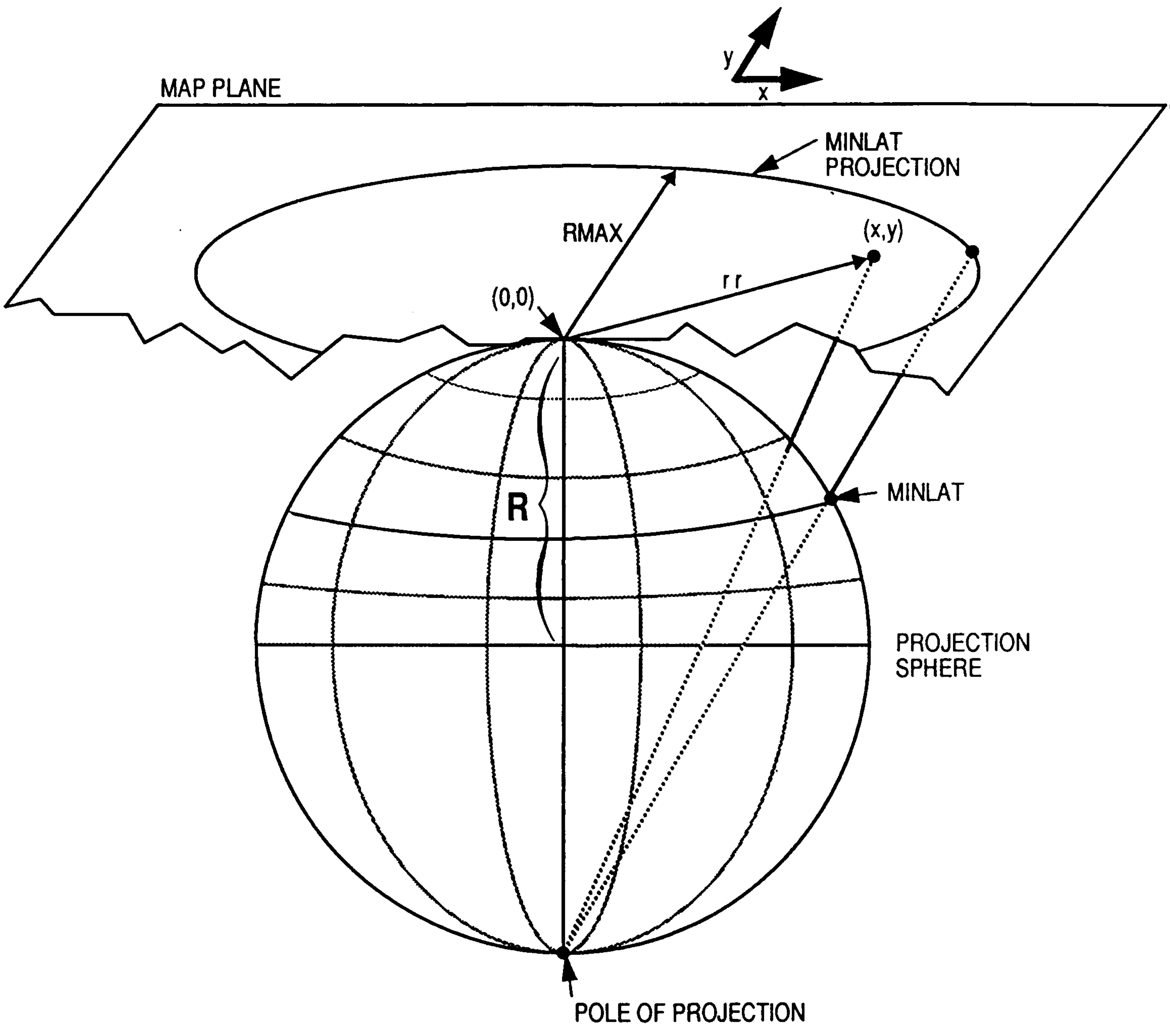


Figure 2. Polar Stereographic Projection.

V. INTERPOLATION AND GRIDDING

Once these two calculations have been made, proceed to set up the input files for the gridding and interpolation routines.

At this point in the process, check each of the computed geographical points for validity. No point digitized lower than the minimum latitude will be placed into the output files. There are 12 output files, each of which is 30 degrees wide and 90 degrees minus minimum latitude tall (figure 3). If a valid data value is encountered, it is then placed in its corresponding data file (i.e., Q1S1-- quadrant one, section one). If not, the latitude, longitude, and "no-data" value are written out to the no-data file. Once these 12 files have been generated, processing steps follow the same order as steps for a non-stereographic data. Appendix A contains the instructions for processing contourable data.

Another problem involved the number of points per inch that the digitizing table supports. On most of our Mercator and corrected Mercator charts, the default of 20 points per inch is sufficient to describe the slope and direction of the contours. However, on a stereographic projection, 20 points is not always enough to describe the contour. At latitudes less than 70 degrees, 20 points per inch should be sufficient. At latitudes higher than 70 degrees, a distance of 1/2 inch on the chart may translate into a span of 90 degrees of longitude. Therefore, we may have 10 or fewer points to describe a contour that spans 90 degrees. This will cause a problem when gridding and interpolating the area. Since each section is 30 degrees wide and each quadrant is 90 degrees wide, there are 360 5-minute cells per section and 1080 5-minute cells per quadrant. Each of these cells must be assigned a data value. With only 10 or fewer points to describe the contour, a great deal of error is introduced and the gridding and interpolation process will be very inaccurate. This problem has a couple of solutions. The first is to have the digitizer place more than 20 points per inch along the contour. This is not a very practical solution because it slows down the person digitizing the chart, and in most cases the number of points needed is far more than the digitizing software will permit. Right now the maximum number of points per inch that can be digitized is 80. This is better than only 20 points, but not enough points to describe the contour adequately. The other solution is to interpolate points (figure 4). This is the method that we employed. Data values are generated between contours if the following criteria are met:

1. A pair of points rests within the same quadrant.
2. The distance between the points is less than 20 deg.
3. The distance between the latitudes is less than 10 min.
4. The data value at each point is the same.

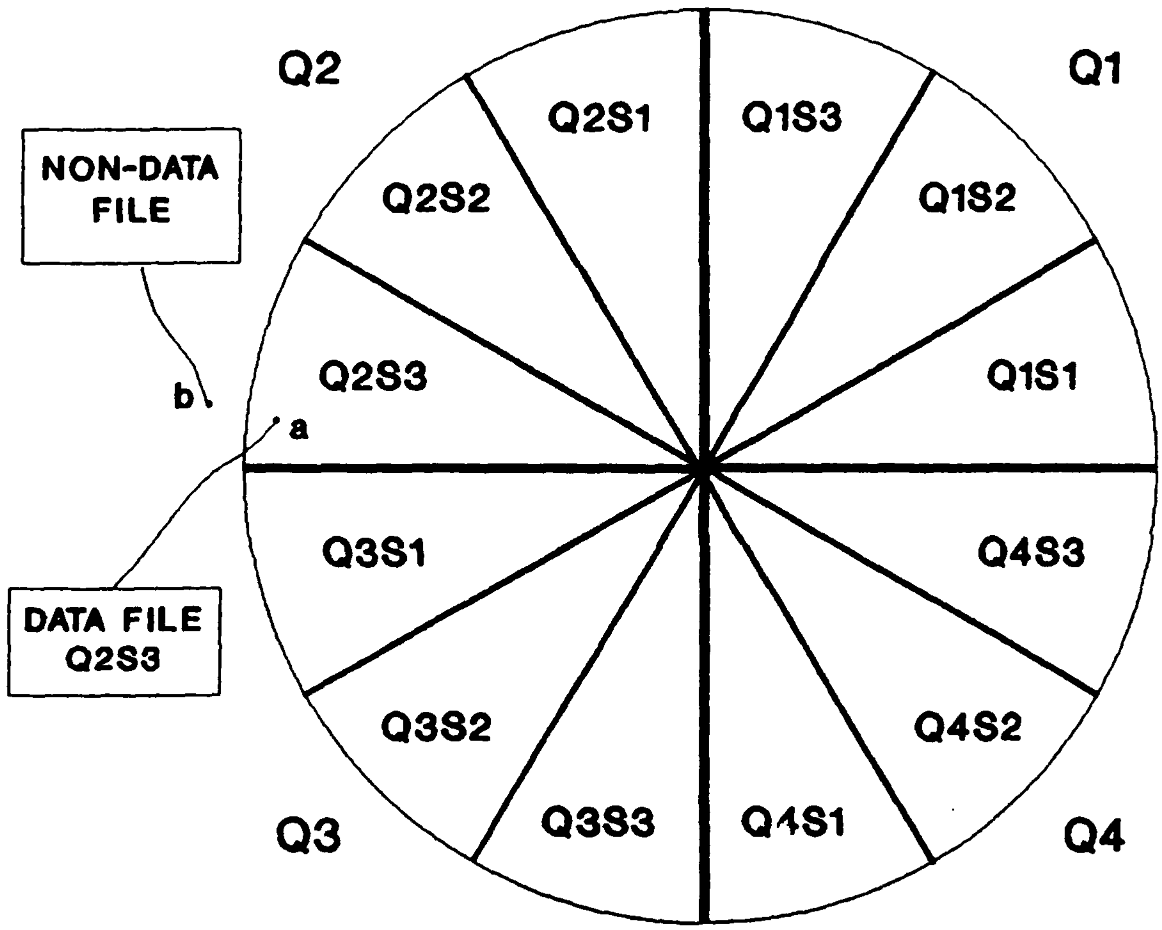


Figure 3. Data Storage.

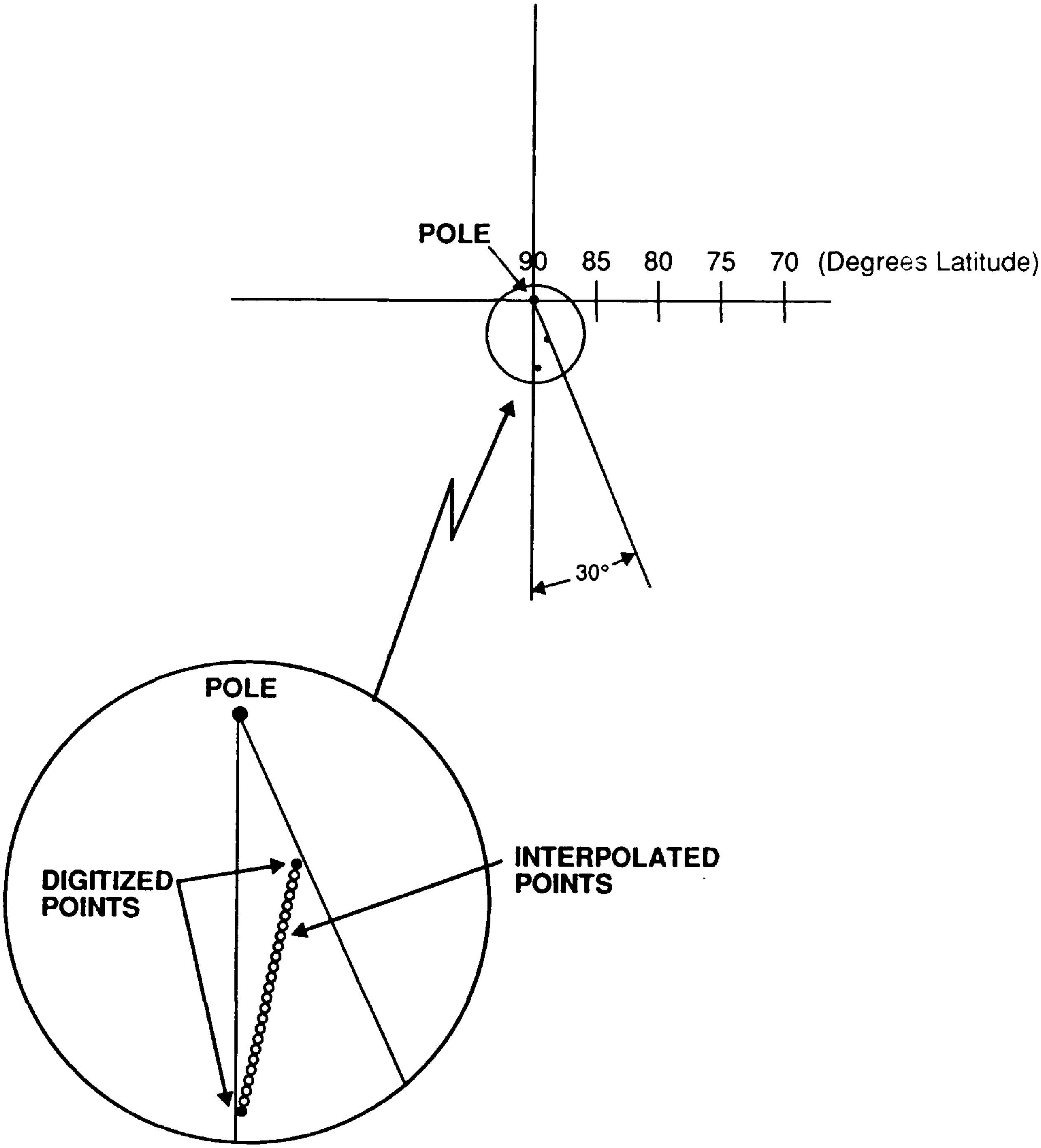


Figure 4. Interpolation Between Digitized Points.

VI. READING THE DIGITIZED DATA TAPE

The following is the flat file format for reading the input data tape. The tape contains ASCII data with a byte block length of 256 characters at 1600 bpi density.

Format	Variable	Description	Comments
A15	Header(1)	Chart type	Header data
.	Header(2)	File name	
.	Header(3)	Chart code	
.	Header(4)	Resolution(points/inch)	
.	Header(5)	X-coordinate of lower left	
.	Header(6)	Y-coordinate of lower left	
.	Header(7)	X-coordinate of upper right	
.	Header(8)	Y-coordinate of upper right	
.	Header(9)	Not used	
.	Header(10)	Not used	
2I6	LLX,LLY	Lower left in table units	
.	LRX,LRY	Lower right in table units	
.	ULX,ULY	Upper right in table units	
I7	Numcon	Total number of contours in file	
A15	Labans(1)	First label	
A15	Labans(2)	Second label	
2I6	Flink,Blink	Forward and backwards links	
I7	Nopts	Number of points in contour. Note that Nopts may be less than zero in some cases. These contours were rejected by the digitizer! Do not store these contours, but it is necessary to read past them on the tape.	
2I6	Tux(),Tuy()	X and Y contour points in table units. Note the control points will be among these points as well as the data.	
.	.	.	
.	.	.	
.	.	.	
.	Tux(),Tuy()	Last point in contour	
A15	Labans(1)	First label	Begin second contour.
A15	Labans(2)	Second label	
2I6	Flink,Blink	Forward and backwards link	
I7	Nopts	Number of points in contour See note above	
2I6	Tux(),Tuy()	X and Y coordinates of points in table units.	
.	.	.	
.	.	.	
.	.	.	
.	Tux(),Tuy()	Last point in contour	Continue for each contour in the file.

APPENDIX A

PROCESSING CONTOURABLE DATA ON THE UNIVAC 1108

This process involves reading a digitized tape and separating the output into two different files. The first is a formatted sequential file consisting of each digitized data point (lat, lon, z, x, y) used as input into interpolating routine. The second is a sequential file consisting of digitized points along "no-data" lines.

The data points are read by the interpolation routine (chrtr3-2) in which values are determined between contour lines by cubic-spline interpolation and then gridded. Data files for neighboring areas should be merged, to assure continuity along the common border. This can be done in the editor. The output of chrtr3-2 is a sequential, unformatted file with data values arranged by row and column. This file must be converted to a formatted type before it can be loaded into an "EAIDS" database. This can be done by running the program formit/sedthk.

Routines

(1) Eaw*prog.sedread/nodata   map:Eaw*prog.mapsedread/nodata
- Input: unit 19.
- Output: data-- unit 11, no-data-- unit 12.
- Needs a digitized contour tape; multiplies values by 1000 (This is done to facilitate the operation of chrtr converts table units to lat and lon, outputs data values with lat and lon to unit 11, and outputs no-data to unit 12.

(2) Eaw*prog.chrtr3-2   map:Eaw*prog.mapchrtr
- Input: unit 11 namelist parameters
- Output: unit 14.
- Interpolates between contour lines; returns a gridded data file. This has been modified to allow processing of a standard Navy ocean area size chart.

(3) Eaw*prog.formit/sedthk
- Input: unit 14; lower left lat and lon; upper right lat and lon
- Output: unit 12.
- Converts chrtr output to a formatted, sequential file for EAIDS input; divides values by 1000; changes values less than .005 to .05.

Step #1: Reading Contourable Data Tape

```
 1) >@asg,tj 19.,u9h//////q,tape#
 2) >@asg,up data*output.,f///3000
 3) >@use 11.,data*output.
 4) >@asg,up nodata*output.,f///1000
 5) >@use 12.,nodata*output.
 6) >@bk1
 7) >@xqt Eaw*prog.sedread/nodata
 8) -->enter # of files on the tape
 9) -->enter tape#
10) >@bk2
```

Step #2: Setting up an Interpolation Run

```
1) >@asg,a data*output.
2) >@use 11.,data*output.
3) >@asg,up chrtr*output.,f///5000
4) >@use 14.,chrtr*output.
5) >@xqt Eaw*prog.chrtr3-2
     $par1
      grid=5.000,schrad=100.00,
      input=0,
      infile=11, ifl=10,
      ibord=15,
     $end
     $par2
      lald=0,lalm=0.00,      (coordinates  defining
      lold=200,lolm=0.00,     area: lower left and
      lard=29,larm=0.00,            upper right)
      lord=240,lorm=0.00,
     $end
6) >@free,r 10    (file is assigned dynamically
7) >@delete 10.    and cause abort of subsequent
                   runs)
```

Step #3: Formatting Chrtr Output for EAIDS Input

```
1) >@asg,a chrtr*output.
2) >@use 14.,chrtr*output.
3) >@asg,up format*output.,f///3000
4) >@use 12.,format*output.
5) >@xqt Eaw*prog.formit/sedthk
   -->input lower left lat and lon (whole deg.)
   -->input upper right lat and lon (whole deg.)
```

The output of this program is a sequential formatted file. The first line of this file is a header which consists of latitude in whole degrees, latitude in whole minutes, latitude hemisphere, longitude in whole degrees, longitude in whole minutes, longitude hemisphere, total number of rows (number of 5-minute cells for the range of latitudes), total number of columns (number of 5-minute cells for the range of longitudes), and row X column data values.

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